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Economies of scale and cost efficiency in the postal services: empirical evidence from Switzerland*

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1. Introduction

Worldwide the postal service sector is quickly changing due to new challenges brought about by rapid technological evolution, changes in customers needs and increasing liberalization of the market.

In the European Union the development of the postal market is regulated by the European Postal Directive (97/67/EC Directive), whose key objectives are the improvement of service quality and the implementation of the internal market, to be achieved through a gradual and controlled market opening to competition and by ensuring the provision of a minimum universal postal service.

To cope with the demands of a more competitive market, each postal company must aim at profitability and efficiency. In fact, market deregulation and the loss of cross-subsidies from telecommunication services force the postal companies to adopt new business strategies focusing on product innovation, diversification, expansion, profitability and cost efficiency.

The Swiss postal market is also affected by these transformations. To act with success in such a new international context, the Swiss postal company (Swiss Post) has to direct its attention to restructuring its organisation and activities and to improving the productive efficiency.

In this scenario, characterized by a general reorganisation of the sector and an increase in competition, the interest in analytical studies investigating the cost efficiency of postal services is high. Despite the fact this subject is topical, in the international literature there are few published studies on the scale and cost efficiency of postal services.

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The most recent studies are those by Norsworthy et al. (1991), Wada, Tsunoda and Nemoto (1997) and Mizutani and Uranishi (2003). Norsworthy et al. (1991) apply a multiproduct cost function to analyse a database consisting of a cross-section of 200 Management Sectional Centers for the United States Postal Service (USPS) operating over the year 1984. The results of their empirical analysis, based on a translog variable cost function, suggests the presence of economies of scale.

Wada, Tsunoda and Nemoto (1997) estimate a multiproduct total cost function of the Japanese mail service by treating the delivery of letter mail and that of parcels as two independent outputs. In their study they consider panel data covering 12 regional postal offices collected over a 15-year period from 1980 to 1994. Using a translog cost function they find evidence for the existence of overall economies of scale. Furthermore, the estimation of a generalized translog function highlights significant product-specific economies of scale for letter mail, but not for parcels.

Mizutani and Uranishi (2003) perform an econometric analysis of economies of scale using a single-output cost model, considering the public company (Post Office) and five other private carriers operating in Japan. Through the econometric estimation of a translog total cost function using a pooled data set over the period 1972-1998, they find no evidence for the hypothesis of the presence of economies of scale for this industry.

The main goal of the present paper is to investigate the scale and cost efficiency of the Swiss Post using an econometric approach. Our empirical analysis considers a sample of postal offices operating in the Italian-speaking part of Switzerland.

The framework of this paper is as follows. In section 2 the cost frontier model for the postal offices is defined and the data set we used is described. Section 3 presents the results of the empirical analysis and gives some insights into scale efficiency of the postal services. Finally, some conclusions are drawn in section 4.

2. Specification of the frontier cost function for postal offices

A frontier cost function identifies the minimum costs at a given output level, input price and existing production technology. It is unlikely that all firms will operate at the frontier. Failure to attain the cost frontier implies the existence of technical and allocative inefficiency. In this paper we consider the estimation of a stochastic frontier cost function using cross-sectional data.[†]

The costs of operating a post office are the costs of building and maintaining the main office, the costs for collecting, processing and delivering mail and the labour costs. The most important factors affecting the classic post office activities are: the total number of customers served, the density of customers in the service area, the size of the post office distribution area and the total number of collected and distributed mail items.

Post offices operate in different service areas with different customer densities. Therefore, an analysis of their cost structure must take account of the fact that the same quantities of mail

[†] Different approaches can be used to estimate a frontier cost function. A good overview is given by Battese (1992), Fabbri, Fazioli and Filippini (1996) and Lovell and Kumbhakar (2000).

can be distributed and collected on differently shaped service areas. For this reason, in the cost model specification it is important to introduce some variables related to environmental characteristics such as the population density. These variables should capture part of the heterogeneity dimension of the distribution and collection process.[‡]

Output is measured by the total number of delivered and collected mail. Inputs consist primarily of labour and capital. The firm's total cost of operating a post office can then be represented by the cost function:

$$C = C(Y_C, Y_D, P_C, P_L, CD) \quad (1)$$

where C represents total cost and Y_C and Y_D are the outputs represented by the total number of collected and processed mail and the total number of delivered mail items, P_C and P_L are the prices of capital and labour, respectively. CD is the customer density, measured as the ratio between the number of customers and the area size measured in square kilometres. The variable CD is introduced in the model as an environmental characteristic. The properties of the cost function (1) are that it is concave and linearly homogeneous in input prices and non-decreasing in input prices and output.[§]

The estimation of cost function (1) requires the specification of a functional form. The translog cost function offers an appropriate functional form for answering questions about economies of scale. However, the small data set available for this study does not suggest the use of this functional form, which is characterised by the high number of coefficients to be estimated.^{**} Therefore, a log-log functional form was used:

$$\ln\left(\frac{C}{P_C}\right) = a_0 + a_C \ln Y_C + a_D \ln Y_D + a_{PL} \ln \frac{P_L}{P_C} + a_{CD} \ln CD + u_i + v_i, u_i \geq 0, i = 1, 2, \dots, N \quad (2)$$

In this specification the error term is composed of two parts: the first, u_i , is a one-sided non-negative disturbance reflecting the effect of costs; the second, v_i , is a two-sided disturbance capturing the effect of noise. The statistical noise is assumed to follow a normal distribution, and the inefficiency term u_i is generally assumed to follow either a half-normal or a truncated normal distribution.

Finally, note that by normalising total cost and input prices by one of the input prices, we impose the theoretical condition that the cost function is linearly homogeneous in input prices.

[‡] Variables for environmental characteristics such as customer density, network length or area size, have been introduced in different cost model specifications for network industries. See, for example, Norsworthy et al. (1991) for the post offices and Roberts (1986) and Filippini (1998) for the electricity distribution companies.

[§] See Cornes (1992), p. 106.

^{**} In the first part of the analysis we used a homothetic version of the translog functional form. However, the econometric results were not satisfactory. All the coefficients of the second term variables were not statistically significant. For this reason we decided to apply an F test to test the hypotheses that all second order coefficients are equal to zero (in this case the translog collapses to the Cobb-Douglas functional form). The observed F value was not significant at 10%.

Data

The study is based on a data set for the year 2001 with information on 47 small local post offices operating in the Italian-speaking part of Switzerland. For each local post office, data on total annual operating costs, hourly wage, price of capital were obtained directly from the regional direction of the Swiss Post company. The price of capital is approximated by the rental price per square meter, which is calculated for each post office by the regional direction of the Swiss Post company. The population density has been calculated using the regional statistics published yearly by the cantonal office of statistics.

As already mentioned, Swiss local post offices operate as local monopolies and therefore operate under quite similar conditions. However, there are still significant differences among them in terms of the level of activities of the offices and the population density.

Descriptive statistics of the variables included in the model are presented in Table 1. With the exception of the price of labour and price of capital, the variables show a high variation.

Table 1 Descriptive statistics of variables included in the model

Variable	Description	1. Quartile	Median	3. Quartile
C	Total cost (SwF)	356'120	498'690	701'210
Y_C	Collected mail	252'860	347'920	636'250
Y_D	Delivered mail	582'990	802'510	1'224'200
P_L	Hourly price of labour (SwF)	58.9	61.2	63.4
P_C	Price of capital (SwF/ m ²)	245	316	361
CD	Customer density (population/km ²)	100	327	923

3. Empirical analysis

Estimation results

The results of the estimation are set out in Table 2. The stochastic cost frontier model has been estimated using a half-normal distribution of the inefficiency.^{††}

The estimated function is well behaved. All parameter estimates have the expected sign and are highly significant. Since total cost and the regressors are in logarithms, the coefficients are interpretable as cost elasticities. The cost elasticities with respect to outputs are positive and

^{††} For the econometric estimation we used LIMDEP, version 8.

imply that an increase in production will increase total cost. A 1% increase in the number of collected mail items will increase total costs by approximately 0.2%. A 1% increase in the number of distributed mail items will increase total costs by approximately 0.6%. This difference can be justified by the fact that generally the delivery function of mail requires more resources than the collection and processing function.

The cost elasticity with respect to population density is negative, indicating that a 1% increase in customer density will reduce costs by approximately 0.04%. This result shows that average costs fall the more densely populated a service area is. However, the impact of the population density on costs is relatively small.

The labour and capital cost shares are positive, implying that the cost function monotonically increases in input prices. In the model, labour costs account for approximately 90% of total postal office costs, while capital accounts for approximately 10% of total costs.

Table 2 Parameter estimates

	Coefficient	t-Value
Constant	-2.303 ***	-5.664
$\ln Y_C$	0.208 ***	3.165
$\ln Y_D$	0.631 ***	10.113
$\ln P_L$	0.909 ***	16.513
$\ln CD$	-0.040 **	-2.175
$\sigma^2(v)$	2.295 **	2.094
$\sigma^2(u)$	0.182 ***	4.130
Log-likelihood function	18.623	

Note: *, **, ***: significant at 5%, 1%, 0.1%, respectively.

Overall economies of scale

Economies of scale may be defined in terms of the elasticity of cost with respect to output.^{‡‡} In a multiproduct setting, economies of scale (*ES*) are defined as those reductions in average cost when all outputs are increased proportionally, holding all input prices and customer density fixed. This is equivalent to the inverse of the sum of the elasticity of total cost with respect to all outputs, in our case Y_C and Y_D :

$$ES = \frac{1}{\frac{\partial \ln C}{\partial \ln Y_C} + \frac{\partial \ln C}{\partial \ln Y_D}} \quad (3)$$

^{‡‡} Return to scale and economies of scale are equivalent measures if and only if the production function is homothetic (see Chambers, 1988, page 72). Here, by using a Cobb-Douglas functional form we are imposing this assumption.

Economies of scale prevail if ES is greater than 1 and, accordingly, diseconomies of scale exist if ES is below 1. In the case of $ES = 1$ no economies or diseconomies of scale exist. Economies of scale exist if the average costs of a postal office decrease as the volume of mail collected and distributed in a service territory of a given customer density increases. We find increasing returns to scale ($ES = 1.19$) for the postal offices in our sample. This result confirms the result obtained, with a similar model specification, by Norsworthy et al. (1991).

Most of the postal offices in our sample are, therefore, small and do not reach the minimum efficient scale.

Cost efficiency

In a stochastic frontier setting, efficiency is measured as the ratio of actual costs to the least-cost level:

$$EFF_i = \frac{E(C | u_i, X_i)}{E(C | u_i = 0, X_i)} \quad (4)$$

Table 3 shows some summary statistics of efficiency scores (EFF) for the postal office of our sample.^{§§}

Table 3 Statistics on efficiency scores (EFF)

	Min	1st Quartile	Median	3rd Quartile	Max
<i>EFF</i>	1.03	1.07	1.12	1.19	1.42

Predicted cost inefficiency figures are sufficiently tight, ranging from 7% of the 1st quartile to 19% of the 3rd quartile, the median value being 12%. More than 50% of the sampled postal offices have mean inefficiency scores lower than 12%. This result shows that the majority of the postal offices considered in our analysis are operating relatively close to the fully efficient cost frontier.

^{§§} EFF is calculated as the ratio of actual costs to the efficient level of costs. The values of inefficiency scores can be interpreted as follows: an efficiency score of 1.3292 means that the firm's cost is 32.92% higher than the cost of an equivalent firm that is efficient. The values of EFF are calculated using the procedure suggested by Jondrow et al. (1982).

4. Conclusion

The paper considers the estimation of a Cobb-Douglas cost frontier function for a sample of 47 Swiss postal offices for the year 2001. The empirical evidence indicates the existence of economies of scale. This result suggests that efficiency gains could result from merging smaller postal offices operating in the same service area or in small adjacent service area. The merger will generate cost advantages only if the two postal offices integrate some collecting, processing and distributing functions so as to act as a single postal office. However, from the economic point of view of the society, the decision to merge smaller postal offices should be based not only on cost effects, but also by considering the potential negative impacts on consumers welfare of this kind of restructuring process. For instance, the closure of a local post office could generate a loss of welfare for the population in terms of an increase in the generalised transport costs to go to the postal office or the loss of a social local meeting point.

Further, the outcome of this analysis shows that approximately 50% of the postal offices included in our sample operate close to the regional standard for efficiency, achieving scores of 12% or lower, in terms of cost difference in relation to the best-practice technology.

References

- Battese, G. E. (1992), Frontier Production Functions and Technical Efficiency: A Survey of Empirical Applications in Agricultural Economics, *Agricultural Economics*, 7, 185-208.
- Chambers, R. G. (1988), *Applied Production Analysis*, Cambridge University Press.
- Cornes, R. (1992), *Duality and Modern Economics*, Cambridge University Press.
- European Parliament and Council (1997), 97/67/EC Directive ("Postal Directive"), European Community, Bruxelles.
- Fabbri, D., Fazioli, R. e Filippini, M. (1996), *L'intervento pubblico e l'efficienza possibile*, Il Mulino, Bologna.
- Filippini, M. (1998), Are Municipal Electricity Distribution Utilities Natural Monopolies?, *Annals of Public and Cooperative Economics*, 2, 157-174.
- Jondrow, J., Lovell, C. A. K., Materov, I. S. and Schmidt, P. (1982), On the Estimation of Technical Inefficiency in the Stochastic Frontier Production Function Model, *Journal of Econometrics*, 19, 233-238.
- Lovell, C. A. K. and Kumbhakar S. C. (2000), *Stochastic Frontier Analysis*, Cambridge University Press.
- Mizutani, F. and Uranishi, S. (2003), The Post Office vs. Parcel Delivery Companies: Competition Effects on Costs and Productivity, *Journal of Regulatory Economics*, 23 (3), 299-319.
- Norsworthy, J. R., Jang, S.-L. and Shi, W.-M. (1991), Productivity and Cost Measurement for the United States Postal Service: Variations Among Regions, in *Competitions and Innovation in Postal Services*, Crew, M. A. and Kleindorfer, P. R., Kluwer Academic Publishers, Boston.
- Roberts, M. J. (1986), Economies of Density and Size in the Production and Delivery of Electricity, *Land Economics*, 62 (4), 378-387.

Wada T., Tsunoda, C. and Nemoto, J. (1997), An Empirical Analysis of Scale Economies, Scope Economies and Cost Subadditivity in Japanese Postal Services, *IPTP Discussion Paper Series*, Nr. 8.

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